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## The role of protected areas in supporting human health : a call to broaden the assessment of conservation outcomes

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1    **The role of Protected Areas in supporting human health: a call to broaden the assessment of**  
2    **conservation outcomes**

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## 11    **Abstract**

12    Ongoing global biodiversity loss has far-reaching consequences for human health and well-being.  
13    While Protected Areas (PAs) have become a major policy instrument for biodiversity conservation,  
14    their role in supporting human health remains unclear. Here, we synthesize both positive and negative  
15    aspects of PAs on different dimensions of human health and provide several theoretical advances to  
16    assess the effectiveness of PAs in promoting human health. We finally identify three major research  
17    gaps requiring urgent attention. Implementing an interdisciplinary research program remains a  
18    priority to better comprehend the linkages between human health, ecosystem services and  
19    conservation policies at global scale. We believe this is key to improve the management of PAs and  
20    their surrounding areas and foster co-benefits for biodiversity and human health.

21

## 22    **Keywords**

23    Conservation; Ebola; Food Security; Human health; Protected Area Effectiveness.

24

## 25    **Highlight**

- 26        • Global biodiversity loss impacts human health and well-being
- 27        • The overall health potential of PAs remains under-recognized
- 28        • PAs have both positive and negative effects on human health and well-being
- 29        • Integrated approaches linking PA management, health and well-being are required
- 30        • In view of Aichi Target 11, we need to assess the linkages between PAs and health

31

32

33

## 34    **Linkages between environmental degradation and human health**

35    Global biodiversity is decreasing at unprecedented rates, as a result of a wide range of anthropogenic  
36    activities [1,2,3]. Such planetary-scale transformations erode the ecosystem services on which society  
37    relies, posing numerous threats to human health [2,3]. Epidemiological studies have argued that a  
38    significant proportion of the global burden of illness is attributable to degraded ecosystems [4]. In  
39    this context, several policy instruments have been developed to bridge environmental and health  
40    policy agendas. For example, the notion that ecosystem health and human well-being are mutually  
41    reinforcing (Box 1) is increasingly being picked up by several international health strategies such as  
42    *OneHealth* [5] or *Planetary Health* [6\*\*]. Similarly, the importance of biodiversity for human well-  
43    being is a core element of the United Nations Sustainable Development Goals.

44    Environmental change and biodiversity loss have been shown to affect existing health burdens,  
45    increasing food insecurity and annihilating rates of human development [7,8]. As a case in point, the  
46    decline in the availability of fish stocks is expected to spell malnutrition in many countries [9].  
47    Furthermore, according to the “biodiversity hypothesis”, reduced contact of people with natural  
48    environments leads to inadequate stimulation of immunoregulatory circuits. Declining biodiversity  
49    in an increasingly urbanized world may thus explain the global rise in the prevalence of allergies and  
50    chronic inflammatory diseases [3]. Rapid population growth, land-use change and increasing overlap  
51    between human and wildlife populations are also related to the recent spread of zoonotic and vector-  
52    borne diseases [10]. Finally, there is increasing evidence that degraded ecosystems also affect mental  
53    health [11].

54    Biodiversity-health linkages have often been explored by looking at ecosystem service flows (e.g.,  
55    water provision) at multiple scales [4,12\*\*], but rarely taking PAs as a leading analytical unit.  
56    Consequently, the health outcomes of PAs have been largely overlooked. Calls for increasing the  
57    coverage of PAs have resulted in growing research addressing their performance in halting  
58    biodiversity loss and securing ecosystem services, with overall positive (albeit modest) outcomes

59 [16]. This scholarly work is gradually broadening its analytical scope to link PAs with larger debates  
60 on human health and wellbeing [17\*]. Yet, a substantial share of the research has focused on  
61 examining predominantly the negative impacts of PAs on human health. This is partly because  
62 conservation planning is inherently spatial, often segregating people from nature and undermining  
63 the well-being of Indigenous Peoples and Local Communities (IPLCs) living close to PAs [13]. Such  
64 potential negative impacts of PAs on human well-being were recognized in the Convention on  
65 Biological Diversity, asserting that PAs should not harm the well-being of IPLCs [14\*\*]. Along these  
66 lines, the Conceptual Framework of the Intergovernmental Science-Policy Platform on Biodiversity  
67 and Ecosystem Services (IPBES) explicitly incorporates the notion of “good quality of life” in the  
68 analysis of institutional arrangements for biodiversity governance [15].

69 In the following section, we review the contributions of PAs to human health and well-being from a  
70 diversity of angles.

71

## 72 **Do Protected Areas support human health?**

73 Despite increasing awareness of the inter-linkages between nature and human health (Box 1), the  
74 overall health potential of PAs remains under-recognized. The few case-based studies assessing the  
75 impacts of PAs on human health have been addressed in different strands of literature, with distinct  
76 theoretical and methodological frames. For instance, while some of the works focus on biophysical  
77 indicators, most of them rely only on notions of subjective well-being or good quality of life [14\*\*],  
78 with few works integrating health and well-being outcomes (Fig. 1).

79 A first body of literature has examined the effectiveness of PAs in delivering ecosystem services with  
80 direct health benefits that would have potentially been eroded had the PAs not been established  
81 [18,19]. For example, it has been shown that nearly two-thirds of the global population relies directly  
82 on PAs for freshwater provision [20]. Similarly, several studies have demonstrated the role of PAs in

83 providing pollination services for food production [21] or in contributing to air purification and  
84 temperature regulation [22]. Many works have also underlined the positive role of PAs in conserving  
85 medicinal plants that sustain both local and global pharmacopeias [23], or the numerous recreational  
86 services provided by PAs, promoting healthy lifestyles [24].

87 In contraposition to this literature, some works have focused on examining the health impacts of PAs  
88 in the light of ecosystem disservices [25]. Under the idea that “nature sometimes kills us”, this  
89 literature argues that IPLCs often carry a disproportionate burden of the health risks derived from  
90 living close to PAs [26\*]. Some of these ecosystem disservices include the spread of vector-borne  
91 diseases [27], animal attacks on humans living close to PAs [28], or lower food security through the  
92 destruction of crops by wildlife [29].

93 Precisely, research on social aspects of conservation has also looked at the impact of some PAs upon  
94 nutrition, showing that displacements of IPLCs and restrictions to resource extraction have often  
95 resulted in increasing food insecurity and malnutrition [30,31] Although the research on PAs and  
96 nutrition is not particularly comprehensive [32], some works have shown that closing off forests to  
97 IPLCs through strict regulations generally leads to reduced food supply and nutrition deficits, e.g.,  
98 anemia [33\*,34].

99 However, other studies have also shown PAs under some circumstances can contribute to alleviate  
100 malnutrition, by maintaining stocks of wild food to later be harvested beyond PA boundaries [35,13].  
101 With most evidence confined to marine environments, this literature has shown that strict PAs may  
102 enhance local nutrition and health by rebuilding wildlife stocks, improving catch rates outside PAs  
103 and helping local people to meet their dietary requirements [36,37]. As for terrestrial ecosystems,  
104 some authors have showed that children stunting is lower close to PAs in the Congo Basin [38].  
105 Moreover, it has also been discussed that the establishment of PAs often introduces new livelihoods  
106 that can result in positive health effects through PA-related income [13,39]. As a consequence, there  
107 is debate on whether the net impact of PAs on local people’s nutrition is positive or negative [14\*\*].

108 Part of this debate is arguably explained by the distinct health effects of PAs under different  
109 management categories [17\*]. Moreover, with the establishment of new PAs promoting co-  
110 management, agrobiodiversity or sustainable production systems in the PA periphery, the potential  
111 of PAs to improve food security should not be under-stated [40,41].

112 Arguably the most well-researched aspect of the link between PAs and health is their effects on  
113 psychological well-being [11,14\*\*]. Research has shown the restorative capacity of PAs and their  
114 role in fostering recovery from mental fatigue, reducing stress levels, assisting cognitive functioning,  
115 and improving the overall psychological state [32,42]. Interestingly, these psychological benefits  
116 have been shown to be higher in areas of greater biodiversity [43,44]. Recent research on nature-  
117 based tourism has documented that visiting PAs often results in increased wellbeing [45]. Indeed,  
118 there is increasing understanding of the positive health outcomes of PAs, with the Australian program  
119 “Healthy Parks, Healthy People” being one of the most paradigmatic examples of this trend [11].

120 Nevertheless, evidence on the impacts of PAs on the well-being of IPLCs is still contentious. While  
121 there are works showing how conservation has improved the health status of many IPLCs near PAs  
122 [14\*\*,39], the opposite also holds true. Due to the colonial legacy of conservation (e.g., displacement  
123 and exclusion), there are numerous cases in which the establishment of strict PAs has contributed to  
124 higher levels of psychological distress and mental illness amongst IPLCs [46,47]. While many IPLCs  
125 indeed find spiritual connections with nature as a source of wellbeing [48], the psychological  
126 implications of exclusionary PAs are significant.

127 Finally, an emerging body of literature is trying to assess the role of PAs in relation to Emerging  
128 Infectious Diseases (EIDs). PAs shape many socio-ecological factors related to disease prevalence,  
129 including land-use, biodiversity, and socioeconomic conditions [49,50]. Hence, PAs may drive  
130 disease prevalence by influencing vector and host presence and by controlling human exposure to  
131 vector species (Box 2). For instance, it is known that deforestation and hunting in non-protected areas

132 disrupt ecological communities with positive knock-on effects on mosquito populations (e.g., through  
133 predation release, improved breeding habitat or increased abundance in dead-end hosts; [10]).

134 However, there is debate on the pathways through which PAs shape the distribution of infectious  
135 diseases (e.g., malaria). While some authors have discussed that PAs could reduce malaria risk by  
136 decreasing human exposure to anopheline breeding habitats [51], others have argued that PAs actually  
137 favor higher exposure to malaria [52]. At the same time, other works have emphasized that PAs could  
138 reduce malaria prevalence through improved socio-economic conditions [53]. Such contradictory  
139 findings are partly explained by different methods and datasets at various spatio-temporal scales, with  
140 certain confounding factors largely unaddressed. As a result, evidence on the role of PAs in shaping  
141 EIDs dynamics remains inconclusive. Moreover, and although positive cases of co-benefits between  
142 biodiversity conservation and disease control exist, it is noteworthy that the complex effects of PAs  
143 on EIDs vary with disease ecology, PA management categories and landscape attributes at various  
144 spatio-temporal scales [51,54].

145

#### 146 **Need for systematic integrative approaches**

147 With progress to achieve Aichi Target 11 of protecting at least 17% of terrestrial and 10% of marine  
148 areas globally by 2020, assessing the role of PAs in supporting human health remains paramount.  
149 Yet, such role cannot be directly extrapolated from studies on the health benefits of nature, given that  
150 PAs, as organizational units embedded within certain socio-political contexts, inevitably alter human-  
151 nature interactions [55]. Responding to recent calls to improve our knowledge of the role between  
152 PAs and human health and well-being [14\*\*], we integrate developments from different research  
153 fronts with the aim of bringing forward the discussion and stimulate new analytical approaches.

154 Assessments of the social impacts of PAs should acknowledge different dimensions of human health  
155 and well-being (Box 1). The evidence to date on positive and negative aspects of PAs derives from



156 an heterogeneous sample of studies addressing very specific aspects of health, which have been often  
157 conducted opportunistically and mostly lacking robust study designs and/or baseline measures  
158 [14\*\*], thus not allowing to guide policy actions. Yet baseline data exists for a number of health  
159 indicators globally, and different long-term health monitoring schemes are being promoted in the  
160 vicinity of many PAs. Examples include USAID’s Health Survey Data, the World Bank’s Living  
161 Standards or the database of the Poverty Environment Network [14\*\*,56], all of which could  
162 potentially be analyzed from a PA perspective. Similarly, in countries such as Canada or Australia  
163 large amounts of indigenous health data exist [57], some of which have been collected near PAs.  
164 There are also numerous PAs with health monitoring programs in neighboring local communities.  
165 Such datasets could serve a purpose in furthering our understanding of the linkages between PAs and  
166 health. Yet, the establishment of monitoring networks that include simultaneous measures of both  
167 aspects of PA effectiveness (ecosystem and human health) should be a priority.

168 PA impacts on health may be direct or indirect, *in situ* or *ex situ* (Figure 2, Panel A). Given that the  
169 core areas of PAs are generally uninhabited, most health impacts are expected at the PA periphery.  
170 Yet, some of them take place at larger scales. For instance, the rising numbers of tourists visiting PAs  
171 challenge the assessment of health impacts only at the local level, but also raise important questions  
172 on “whose health” is being evaluated. Research on the links between PAs and health should ideally  
173 account for both local and non-local impacts, avoiding biased samples (only surveying tourists) that  
174 serve certain political or economic agendas. Moreover, it is also important to evaluate the role of PAs  
175 in supporting future health. For instance, many PAs conserve plants underpinning the future  
176 provisioning of medicines for both local and prospective global uses [58]. Assessments of the linkages  
177 between PAs and health should thus find a balance between the health prospects of both present and  
178 future generations.

179 Along these lines, it is crucial to recognize that health is also dependent on the socio-economic  
180 context. Socio-economic factors are known to affect the conservation effectiveness of PAs [59]; yet,

181 they are rarely considered when evaluating PA impacts on health or well-being. Aspects such as PA  
182 permeability have been also argued to impact health [54]. For example, strict PAs (IUCN Category  
183 I) will have different impacts than PAs with sustainable use of natural resources (Category VI). PA  
184 size and isolation will also play an important role. Panel B in Figure 2 illustrates a few alternative  
185 settings of PAs varying in governance type, size and isolation, particularly due to land-use changes  
186 at the PA periphery. Here we deliberate on the potential health consequences of such scenarios, while  
187 stressing that empirical evidence is largely lacking and that analytical approaches accounting for PA  
188 attributes are urgently needed.

189 PAs of Type A (i.e., small size, strict protection and highly degraded periphery) have often induced  
190 exclusion of IPLCs (through restrictions on resource use), undermining food security and well-being  
191 [35,60\*\*]. Malnutrition increases immunity deficiency and susceptibility to infection. IPLCs living  
192 in degraded PA peripheries are thus potentially more vulnerable to zoonotic and vector-borne  
193 diseases, following changes in the distribution of vector species. Potential benefits associated to Type  
194 A would be contingent on infrastructure development and poverty alleviation initiatives, which  
195 should be rarer for small areas of strict protection compared to Types B and C. Such developments  
196 could bring about improvements in healthcare delivery; yet, these are unlikely to counterbalance most  
197 health costs.

198 Types B and C may instead lead to more co-benefits for both health and biodiversity. Increased PA  
199 size associated to sustainable resource extraction either within Type B or within the buffer zone of  
200 Type C would decrease health costs associated to alienation and malnutrition, while incomes from  
201 tourism could bring livelihood diversification and poverty alleviation in the periphery (Type B, Fig.  
202 1). From the perspective of EIDs, the evidence is still inconclusive, and outcomes may well be  
203 disease-dependent as well as context-specific (Box 2). Yet, we expect that large core areas of strict  
204 protection surrounded by sustainable-use peripheries (Type C), would decrease the probability of  
205 EIDs expansion, while best conserving species and habitats. In this case, a well-managed buffer zone

206 would hold a significant portion of semi-natural habitats allowing for sustainable use by IPLCs, with  
207 benefits in terms of livelihoods, nutrition and well-being.

208

## 209 **Future research directions**

210 While research on the linkages between human and ecosystem health grows, this review stresses an  
211 urgent need to address specifically the role of PAs in supporting human health. In this review, we  
212 have identified important research gaps that preclude us from developing a clear picture of the overall  
213 health effects of PAs. These include among others: i) integration and comparison of the heterogeneous  
214 set of health dimensions, ii) a comprehensive overview of different human population targets for  
215 health assessments (i.e. whose health is being evaluated; within and beyond PAs), and iii) a context-  
216 dependent analytical framework incorporating spatial, environmental and socio-economic factors  
217 (including PA management types). Additionally, while studies on the effectiveness of PAs in  
218 safeguarding biodiversity are becoming ever more common, we are not aware of any single study  
219 linking effectiveness of biodiversity conservation with health outcomes. Research at all these fronts  
220 will shed light into many ongoing debates, and be able to clarify why some PAs may promote health  
221 while others not.

222 In order to tackle the abovementioned gaps, we highlight that tools and datasets are already available  
223 to support substantial advances, while others need yet to be implemented. For instance, many of the  
224 health monitoring databases mentioned above could be used to develop a more integrated overview  
225 of the health impacts of PAs. Similarly, diverse large-scale environmental, geographical and socio-  
226 political datasets can already be linked to disentangle the effects of particular health indicators in  
227 different contexts. Research systematically comparing the health outcomes of PAs under different  
228 management categories is particularly called upon and a straightforward step given the available data.

229 At finer scales, emphasis should be placed on buffer zones around PAs in order to disentangle the  
230 complex linkages between land-use change, natural resource use and socio-economic conditions and  
231 understand how they influence different aspects of health, for instance linking nutrition and emerging  
232 infectious disease impacts. Replicated and standardized studies of this type in multiple contexts are  
233 very much in order.

234 All things considered, however, we view as paramount the need to strategically develop and  
235 implement, integrated, large scale co-monitoring schemes in order to assess synergies and trade-offs  
236 between biodiversity conservation and human health. Monitoring biodiversity responses to human  
237 disturbance inside PAs, as well as in the PA periphery and buffer zones, and understanding how this  
238 in turn affects different dimensions of human health across different types of PAs is an urgent priority.

239 We end with a note of warning regarding reports of negative impacts of PAs on human health. While  
240 empirical research on the reality of health risks is desirable, caution is needed when communicating  
241 research outcomes to wider audiences in order to avoid misinformed and unsupported health concerns  
242 undermining long-term conservation efforts [61].

243

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255 \*of special interest

256 \*\*of outstanding interest

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474

476 **Box 1. Human Health, Well-Being and Ecosystem Health**

477 Numerous frameworks exist for conceptualizing health and well-being, ranging in focus from the individual  
478 to the nation, and hailing from such diverse disciplines as anthropology, economics or epidemiology [62,63].  
479 Such frameworks have used a wide array of indicators to measure the health, ranging from mortality (e.g.,  
480 child mortality), morbidity (e.g., prevalence, incidence), health status (e.g., high blood pressure), nutritional  
481 (e.g., children stuntedness), social health (e.g., substance abuse), or health-system (e.g., healthcare delivery)  
482 indicators.

483 Although a full review of these frameworks is beyond the scope of this paper, it is important to note that despite  
484 their theoretical differences, most of these works share a general vision of linking human and ecosystem health  
485 [18,64]. Frameworks in this vein resonate with indigenous peoples' philosophical concepts of living in  
486 harmony with nature (e.g., Andean notion of Mother Earth), identifying kinship between people and nature as  
487 a determinant of human well-being [15]. Overall, these ever-more holistic definitions of human health  
488 (reflecting the origin of the word, derived from the Greek 'hal' or 'whole') are providing new opportunities  
489 for conservation managers to play a greater role in supporting human health than in the past [32]. As a result,  
490 there have been recurrent calls for a shift from purely biophysical measures of health to broader well-being  
491 indicators, targeting life satisfaction, good quality of life, or happiness, to cite just a few [62,65]. Many of  
492 these indicators have also started to gain prominence in environmental discourses (e.g., *Sumak Kawsay* in  
493 Ecuador; Gross National Happiness in Bhutan).

494

## Box 2. Protected Areas or their periphery as hotspots of infectious disease emergence?

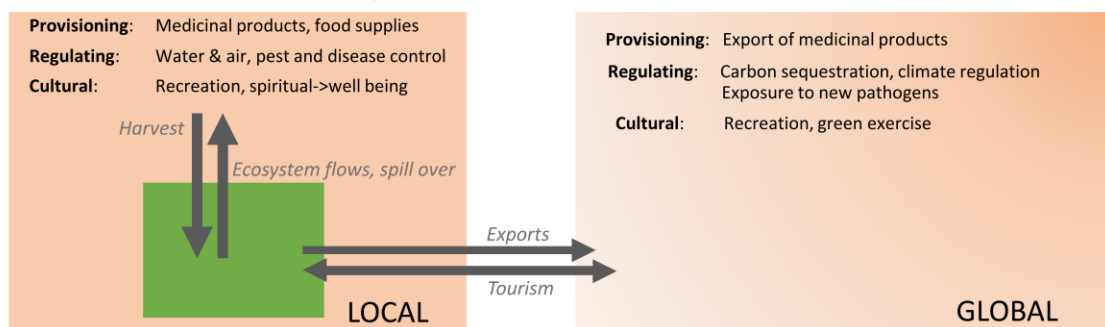
Up to two-thirds of known human infectious pathogens have emerged from animals [66]. This transmission from other species to humans fits with pathogen ecology and evolution, but the opportunities for animal-to-human pathogen spillover are higher with increasing human encroachment in natural habitats, particularly in the tropics [67]. Major disease hotspots appear to be at the interface between natural and degraded ecosystems, such as at the periphery of PAs. However, few studies have taken PAs as a leading analytical unit in epidemiological studies [53].

A topical case is that of Ebolaviruses, extremely contagious pathogens causing lethal hemorrhagic fever disease in humans and animals with high fatality rates. They have been repeatedly reemerging across the African equatorial belt since 1976 [68]. Despite the multiple Ebola outbreaks, we still have limited understanding of the reservoir host species and the environmental contexts favoring animal-to-human transmissions [69]. For instance, RNA of the Zaire Ebola virus (EBOV) has been detected in multiple wildlife species such as three species of bats, duikers (*Cephalophus* species), gorillas (*Gorilla gorilla*), chimpanzees (*Pan troglodytes*) and various rodents, remaining debatable which are the natural reservoirs [70,71].

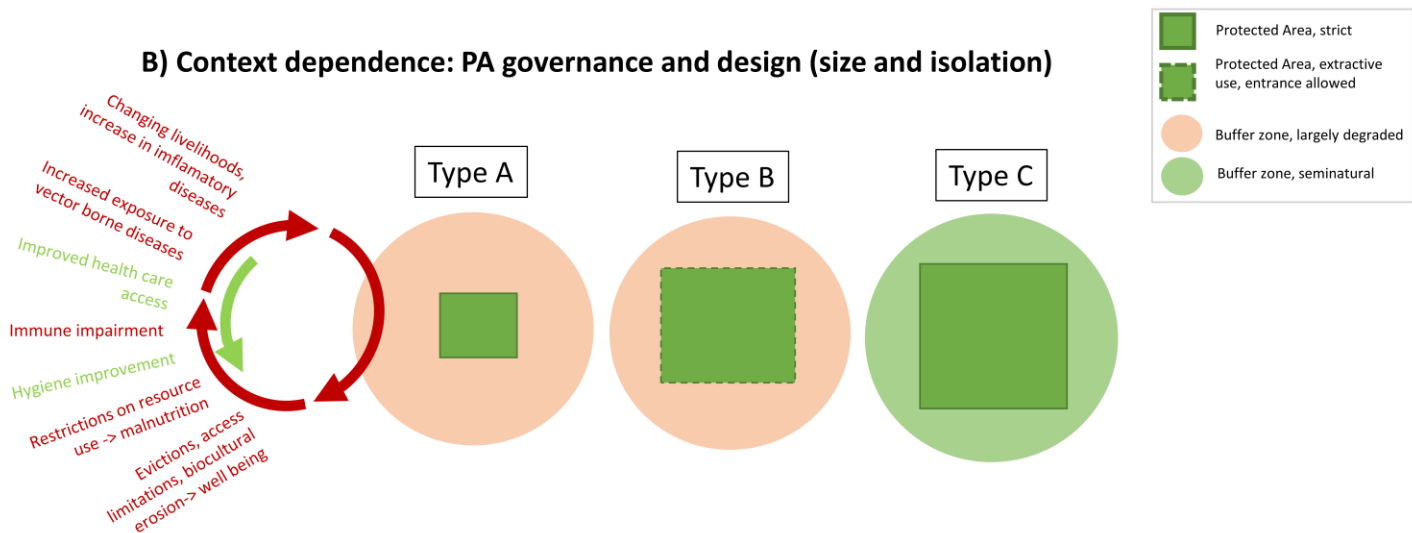
Ebola outbreaks have indeed been linked to contacts with wildlife. The cases in Gabon and DRC, in proximity to Odzala Kokoua National Park in 2001-2003 (Fig. 2), started when locals found and manipulated carcasses of infected mammals at the PA periphery [72]. Hunting pressure is high in North-eastern Gabon and affects large-scale animal communities [73], highlighting the role of bushmeat familial consumption as a high-risk behavior in these local communities. Yet outbreaks have also been linked to environmental change in Central and West Africa, with index cases in humans occurring in hotspots of forest fragmentation [74\*]. The maps below (Fig. 2) illustrate how Ebola emergence locations (marked A, B and C) correspond to areas of recent deforestation, in the periphery of the Odzala Kokoua National Park. This suggests an interaction between land-use change and bushmeat hunting enhancing zoonotic disease outbreaks. While the role of PAs in the spatial dynamics of EVD outbreaks has not been investigated, caution is needed when interpreting spatial patterns. Although PAs are sometimes portrayed as EIDs hotspots because of the species they protect within [52], EIDs emergence might instead be attributable to the processes of fast land degradation happening beyond their borders.

Given that EIDs are responsible for over one billion human cases per year, we urge research to investigate i) how the interaction of deforestation and bushmeat consumption affect wildlife communities and particularly the host species around PAs; ii) how this resonates into spatial dynamics of EID emergence taking into account variation in livelihoods, human malnutrition and variation in PA governance and law enforcement; iii) the feasibility of an international protected area network of wildlife and human health monitoring combined with public education about zoonotic diseases particularly at PA periphery [75].

## A) Scale of impacts on health related Ecosystem Services



## B) Context dependence: PA governance and design (size and isolation)



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531

532 **Figure 1. Linkages between human health, ecosystem services and PA management.** Panel

533 A. Scale of impacts on health through different ecosystem services. Impacts can be local or global,

534 within or outside the PA. Processes marked in cursive. Panel B illustrates different PA settings.

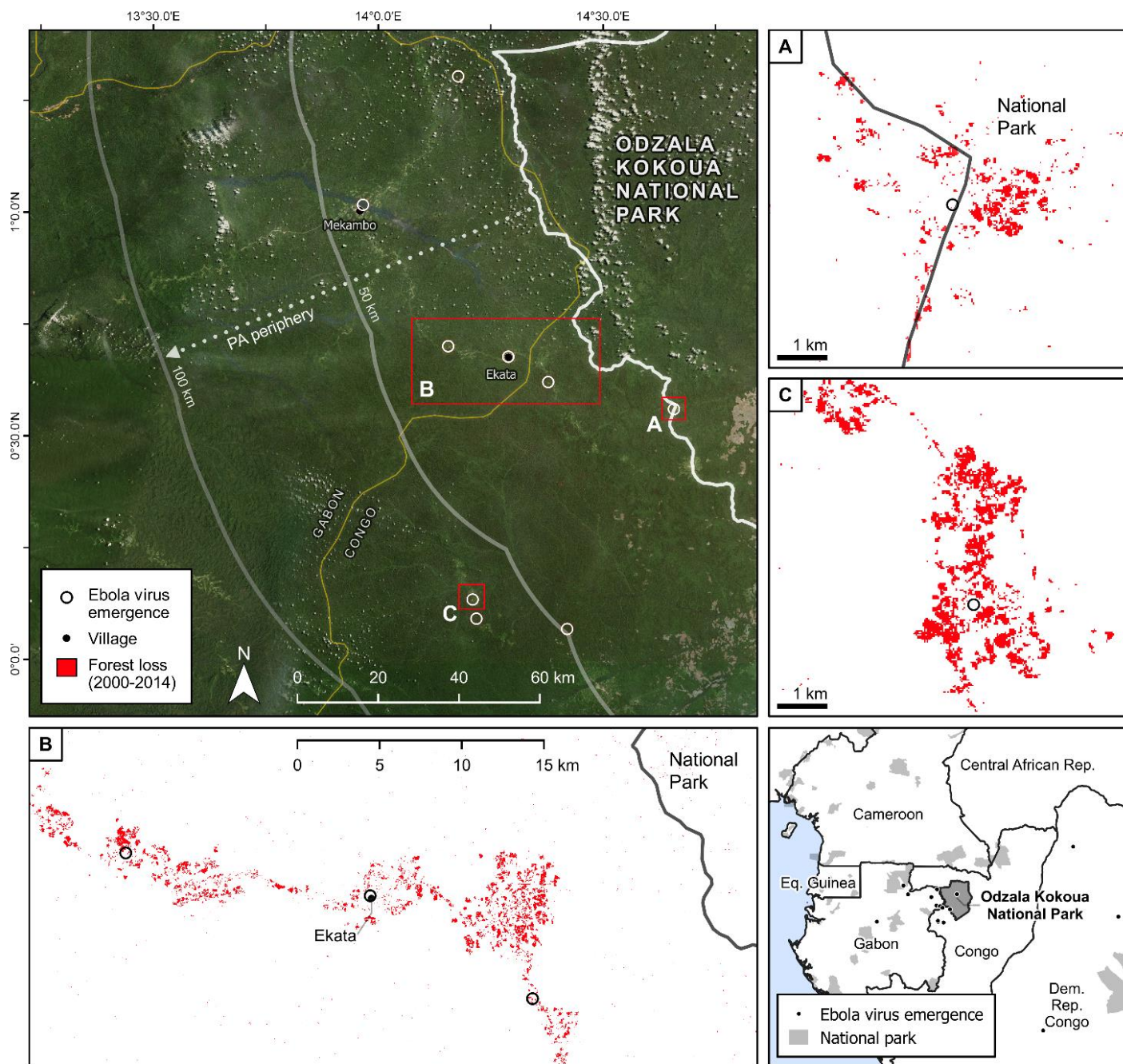
535 Protected areas can have different restrictive uses, from complete exclusion of human actions to

536 sustainable extractive uses of different types. In addition, they vary in their spatial design, with

537 aspects of shape, size and isolation affecting both biodiversity as well as health impacts.

538

539



**Figure 2. Ebola virus emergence in the periphery of Odzala Kokoua National Park in relation to forest loss patterns (Congo – Gabon).**